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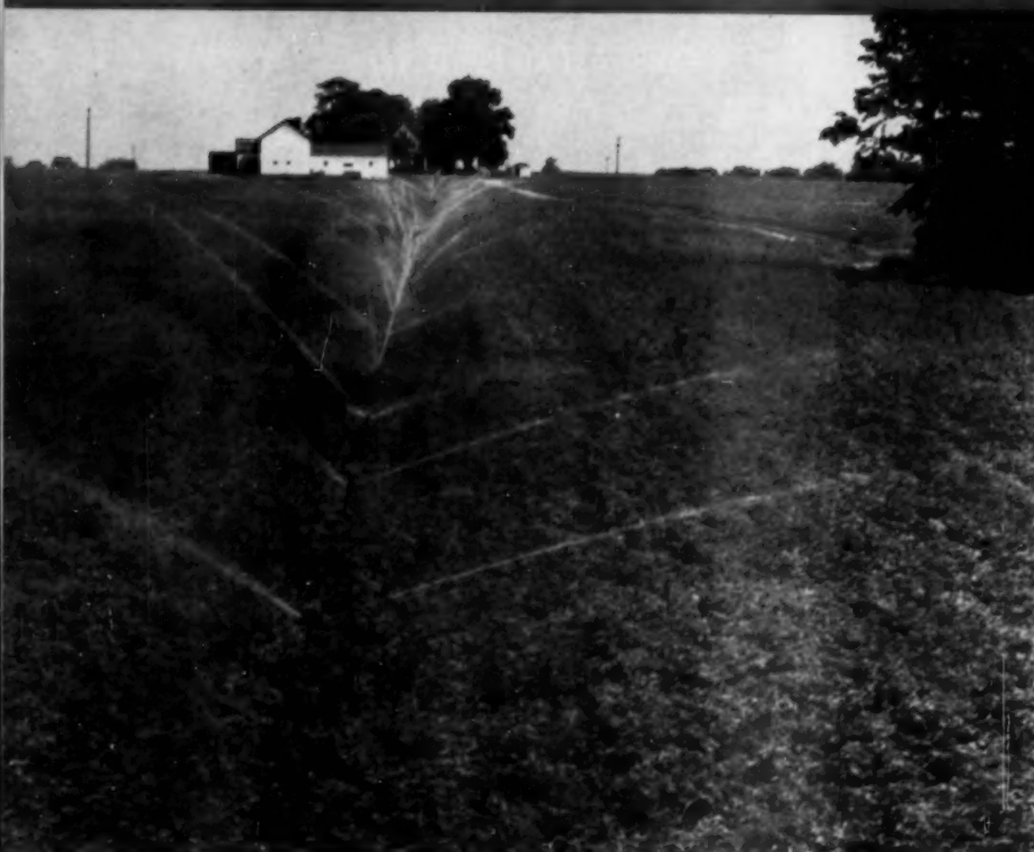

Irrigating New Jersey Potatoes

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NEWS AND REVIEWS

OUR COVER PICTURE—*This photo shows the use of portable aluminum pipe with rotating sprinklers. It is used on approximately 80 per cent of the potato acreage in central New Jersey. Photo courtesy Rutgers University.*

MECHANICAL DAMAGE TO POTATOES DURING HARVESTING AND HANDLING OPERATIONS IN THE RED RIVER VALLEY OF MINNESOTA AND NORTH DAKOTA[1]

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Excessive deterioration in market quality of potatoes during harvest and movement from field to consumer has been a problem of potato producers and shippers ever since potatoes have been grown for sale.

In 1948 the Red River Valley Potato Research Laboratory was established at East Grand Forks, Minnesota, in the heart of a large potato growing area. This laboratory provided ideal facilities for studying the problems of harvesting, handling, storing, and transporting of potatoes.

It was recognized that one of the first problems to be attacked was reducing the mechanical injury of potatoes during harvest and movement from the field to the consumer.

To proceed most efficiently in improving harvesting and handling equipment, it was necessary to survey the existing harvesting and handling operations to learn which one of these contributed most to the deterioration of potatoes. The results of this survey would thus indicate where mechanical improvements would most effectively reduce handling losses.

This paper presents the findings of such a survey during the 1949 season. The survey furnished data on stages in handling at which bruising occurred, attempted to determine the causes of variability in mechanical injury of potatoes from field to field, and tried to learn the effects of bruising during handling on storageability of potatoes. To help determine the causes of field-to-field variations in mechanical injury, careful notes were made on field soil conditions and climatic conditions at time of harvest, stage of vine maturity at harvest, method of vine killing used, distance from field to storage, *etc.* for each field surveyed. To study the effects of bruising during handling on storageability, samples of potatoes were obtained at various stages of the harvesting operation and were carefully stored without further damage to determine whether changes in grade would occur while the potatoes were in storage.

Since this survey was conducted, potato harvesting methods in the Red River Valley area of Minnesota and North Dakota have changed considerably with mechanized harvesting equipment to a great extent replacing the old digger-hand picking system (3). Nevertheless, the

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harvesting and handling methods used when this survey was made still apply to a large extent particularly in the warehouse handling operations.

Review of Literature

Mechanical injury to potatoes can (and usually does) occur at each stage in the movement of potatoes from the field to the consumer. Inasmuch as Rose and Cook (4) published a comprehensive review of the literature on this subject up to 1947, no attempt will be made here to review the earlier work. Despite improvements in digger design and operation, Schrumpf (7) found that in 1946 and 1947 the digging and picking operation alone caused an average tuber bruising of 11.4 per cent of which 2 per cent were major bruises. This was approximately one-half as much injury as that caused by the same operation 15 years earlier. Todd and Shuler (8) found that diggers caused approximately 7 per cent injury to potatoes and showed that such injury could be greatly reduced by protective padding of the digger and reducing speed of digger travel.

In a recent comprehensive study on sources of mechanical damage to potatoes during harvest, Davis (1) found that about 43 per cent of the potatoes examined had been mechanically damaged by the time they were packed in the warehouse. The distribution of this damage for the various handling operations was as follows: digging, 12.1 per cent; hauling to storage, 1.6; binning, 8.1; cellar sacking, 4.3; hauling from cellar to warehouse, 0.8, and warehouse packing, 16.6 per cent.

Materials and Methods

The original plan of this study was to determine the effects of various harvesting and handling operations from digging to the time the potatoes were offered to consumers in the retail store. However, because of various difficulties encountered it was possible to study only the mechanical damage which occurred to the time the potatoes were bagged for shipment at the shipping point.

Data on the effects of harvesting operations on mechanical injury to potatoes were obtained on thirteen farms in the vicinity of East Grand Forks, Minnesota, and Grand Forks, North Dakota. At each farm a picker-basket sample of potatoes (32-40 pounds) was taken and examined for mechanical injury at each of the following stages in the harvesting operation: (1) from the ground behind the digger, (2) from the basket after picking, and (3) from the field sacks into which the picking baskets were emptied. In order to obtain a measure of the variability within a field, this sampling procedure was repeated on each farm as the harvesting proceeded until three samples had been examined at each of the stages mentioned.

To determine the effects of field loading and hauling to the warehouse on mechanical injury, three samples of potatoes were removed from the field truck after its arrival at the warehouse and examined for mechanical injury. To obtain a representative sample of the load, one sample was obtained from a sack on the top of the load, one from the center, and one from the bottom of the load.

To determine the effects of bin filling on tuber injury, three samples were obtained from various levels in the bin as the bin was filled with potatoes from the field being surveyed.

To help determine causes for variability in mechanical injury of potatoes from different fields, data about the following items were recorded for each field surveyed: climatic and soil conditions, stage of vine maturity at digging, method of vine killing used, distance from field to warehouse, speed of truck, truck padding, method of loading, and method of bin filling.

In order to determine the effects of mechanical injury on the storageability of potatoes, samples from two fields taken at the stages indicated were placed in corrugated paper egg crates to prevent further injury. The crates were then stored at the Red River Valley Potato Research Center and re-examined for mechanical injury and decay after six months' storage.

The effect of packing operations on mechanical injury to potatoes was studied in nine warehouses. As in the field operations, three samples were removed at each of several stages in the packing operation and examined for mechanical damage. In these examinations only fresh injuries were recorded. The stages at which potatoes were sampled varied somewhat from warehouse to warehouse depending on the operations in each. In general, samples were obtained from the bin, from the hopper at the end of the conveyor line before the potatoes enter the washer, as the potatoes left the washer, and from the sacks at the end of the grading line.

Four types of mechanical damage were recorded: cuts, bruises, cracks, and skinning. Each of the first three types of damage was classified as "slight" (within the tolerance for U. S. #1 grade), "moderate" (within the tolerance for U. S. #2 but not within that for U. S. #1 grade) and "severe" (not within the tolerance for U. S. #2). The total weights of tubers having slight, moderate, and severe injury were recorded for each type of damage. A tuber that showed more than one type of mechanical injury (*e.g.* cuts *and* bruises) was classified on the basis of the more serious damage present. Thus, the total mechanical damage incurred by any lot is the sum of the various types of injury recorded. Skinning damage was estimated and recorded as per cent of the skin removed. All data regarding mechanical damage other than skinning are presented throughout this paper as per cent by weight.

The general soil type on which these field surveys were conducted is a silty clay loam. This soil is free from stones but, depending on the degree of compaction and moisture level, may vary in structure from fine granular to extremely cloddy at potato harvest time.

Ten of the thirteen fields involved in the field-to-warehouse survey had been planted with the variety Triumph and three with the variety Pontiac. The two lots stored in egg crates were Triumph. Of the nine lots involved in the bin-to-sacking survey, six were Triumph and three Pontiac.

RESULTS

Influence of Harvest Operations on Mechanical Damage

The effects of field-to-warehouse operations on the incidence of cuts, bruises, and cracks are shown in table 1, together with the total damage due to these three types of injury. Field-to-field variations in these

types of injury at the end of harvest operations are shown in table 2.

Inasmuch as the incidence of cut tubers did not increase after digging (Table 1), it is apparent that the digging operation itself was the only one which caused this type of injury. The percentage of cut tubers varied significantly from field to field and ranged from zero in field No. 3 to 17.9 per cent in field No. 2 (Table 2). Notes on digger operation indicate that in all fields where the incidence of digger cuts was high, the digger was operated at depths of 4½ inches to 5 inches. In fields where few digger cuts occurred, the digger point was 7 to 8 inches deep during digging.

Damage due to cuts was about equally divided between slight, moderate, and severe. Approximately 2 per cent of the potatoes handled were reduced in grade from U. S. No. 1 to U. S. No. 2 or lower because of cuts incurred during field-to-warehouse operations.

TABLE 1.—*Incidence and severity of cuts, bruises, and cracks on potatoes at various stages of harvest operations.*

Type of Damage and Stage in Harvest Operations	Amount of Damage[1] (Means of 13 Fields)				Ranges in Total Damage for 13 Fields
	Slight	Moderate	Severe	Total	
	Per cent	Per cent	Per cent	Per cent	Per cent
Cuts:					
Behind digger	1.0	0.8	1.3	3.1	0- 9.7
In picking basket	0.9	0.7	1.1	2.7	0- 8.8
In field sack	1.0	0.6	0.6	2.2	0.2- 4.7
On truck at warehouse	1.0	1.1	1.0	3.1	0- 8.6
In bin at warehouse	1.3	1.0	1.0	3.3	0-17.9
L.S.D., 1 per cent level	....	....	....	n.s.	....
Bruises:					
Behind digger	4.7	0.3	0.2	5.2	0-11.4
In picking basket	6.0	0.5	0.2	6.7	0.5-25.3
In field sack	9.1	0.5	0.1	9.7	1.2-24.3
On truck at warehouse	13.9	0.7	0.2	14.8	2.2-35.0
In bin at warehouse	16.4	1.5	0.5	18.4	3.4-38.9
L.S.D., 1 per cent level	....	....	....	2.8	....
Cracks:					
Behind digger	1.2	0.6	0	1.8	0-13.6
In picking basket	1.1	0.1	0	1.2	0- 4.4
In field sack	3.4	0.2	0	3.6	0-15.7
On truck at warehouse	2.9	0.4	0	3.3	0-16.2
In bin at warehouse	4.2	0.5	0	4.7	0-20.3
L.S.D., 1 per cent level				1.8	....
All types:					
Behind digger	6.9	1.7	1.5	10.1	
In picking basket	8.0	1.3	1.3	10.6	
In field sack	13.5	1.3	0.7	15.5	
On truck at warehouse	17.8	2.2	1.2	21.2	
In bin at warehouse	21.9	3.0	1.5	26.4	

[1]Per cent by weight.

TABLE 2.—*Incidence of various types of damage on potatoes in the bin immediately after harvest on thirteen farms in the Red River Valley.*

Field No.	Variety	Potatoes with Indicated Type of Injury:[1]			Total Damage[2]	Skinning
		Cuts	Bruises	Cracks		
		Per cent	Per cent	Per cent	Per cent	Per cent
1	Triumph	2.3	15.6	0.0	17.9	15.0
1A	"	2.3	15.6	0.0	17.9	15.0
2	"	17.9	9.8	3.9	31.6	17.5
3	"	0.0	13.1	3.9	17.0	11.2
4	"	4.9	13.5	2.1	20.5	15.0
5	"	2.7	18.5	20.3	41.5	38.3
5A	"	0.3	34.6	9.7	44.6	15.0
6	"	2.6	17.5	1.3	21.4	15.0
7	"	2.8	33.9	6.7	43.4	11.3
8	"	2.7	19.8	5.0	27.5	15.0
10	Pontiac	1.8	4.5	0.0	6.3	15.0
11	"	1.6	38.9	5.6	46.1	20.0
15	"	0.8	3.4	3.4	7.6	0.0

[1]Per cent by weight.
[2]Excluding skinning.

The data on bruises incurred during field-to-warehouse operations (Table 1) show that digging bruised an average of 5.2 per cent of the total weight of potatoes dug. Each subsequent handling operation caused further bruising so that by the time the potatoes were placed in the bin 18.4 per cent of them had been bruised. Approximately one-fourth of the total bruising occurred during digging, another one-fourth during truck loading and in the haul from field to warehouse, and one-fifth during the bin-filling operation.

Bruising varied considerably from field to field (Table 2). Only 3.4 per cent of the potatoes from field No. 15 were bruised, whereas 38.9 per cent of those from field No. 11 were bruised by the time they reached the warehouse bins. Both fields were of the Pontiac variety and had been roto-beat to remove vines two to three weeks before digging. Soil conditions at the time of digging were similar, but the air temperature when field No. 11 was dug was 58° F. and when field No. 15 was dug, 75° F. The lower air temperature during digging of field No. 11 may have had some effect on retention of turgidity by the tubers and thus increased their susceptibility to bruising. However, data from other fields dug at the same temperature indicate that factors other than temperature were more important in determining the bruising. In fields No. 11 and No. 15 the digger was operated at approximately the same speed. However, the digger used in field No. 11 had three pairs of shakers while that used in field No. 15 only two pairs. In field No. 11 the potatoes were bounced considerably during digging, sometimes as high as six to eight inches.

Only 2 per cent of the potatoes were reduced in grade because of bruises. However, bruises which are not serious enough to score against grade at the outset can develop into grade defects during storage, as will be pointed out later.

As shown in table 1, 1.8 per cent of the tubers showed cracks following the digging operation. Picking into baskets did not result in further cracking. Dumping into field sacks, however, approximately doubled the percentage of potatoes cracked. Bin filling caused a further increase in cracking with the result that 4.7 per cent of the potatoes in the bin had this defect in some degree.

As was the case with the other types of mechanical damage, cracking of tubers varied considerably among the fields surveyed (Table 2). In three fields no cracking occurred, whereas 20.3 per cent of the potatoes from field No. 5 had cracks when they reached the warehouse bin. Nothing in the methods of handling gives a clue as to the reason for the large incidence of cracking in potatoes from field No. 5. However, the plants (Triumph variety) in this field were 70 per cent green when roto-beat one week before digging. All the other fields of Triumph potatoes which had green vines had been roto-beat two to three weeks before harvest. Possibly the relatively short interval between vine removal and harvest prevented proper maturing and loss of turgidity of the tubers prior to harvest.

As an average of the thirteen fields, 0.5 per cent of the crop was reduced in grade because of cracked tubers.

The average estimated percentages of skinning of potatoes resulting from field-to-warehouse operations are given in table 3. Only a slight amount of skinning resulted from the digging and picking operations. Dumping potatoes into field sacks significantly increased the incidence of skinned potatoes. The loading and hauling operation approximately doubled the amount of skinning. Bin filling again doubled the amount of skinning, with the result that potatoes in the bins had 15.6 per cent of their periderm skinned off.

TABLE 3.—*Estimated incidence of skinning on potatoes at various stages of harvest operations.*

Stage in Harvest Operations	Potatoes Skinned (Means of 13 Fields):	Ranges in Skinning for 13 Fields
	Per cent	Per cent
Behind digger	1.0	0- 4.3
In picking basket	1.6	0- 5.5
In field sack	3.5	0-11.7
On truck at warehouse	7.6	0-30.0
In bin at warehouse	15.6	0-38.3
L.S.D., 1 per cent level	2.3	....

Field-to-field variations in the amounts of skinning at the end of harvest operations are shown in table 2. Although the degree of skinning was remarkably uniform from field to field, two fields were outstanding exceptions. Potatoes from field No. 15 showed no skinning when they reached the bin, whereas those from field No 5 had 38.3 per cent skinned area. Potatoes from field No. 15 were Pontiacs roto-beat two weeks before digging; those from field No. 5 were Triumphs roto-beat one week

before digging. Undoubtedly, this difference in variety and in period between vine removal and digging played some part in the resistance of tubers to skinning. However, it is also apparent from the data on cuts, bruises, and cracks that potatoes from field No. 15 were handled more carefully than those from field No. 5.

To summarize the effects of harvesting operations on mechanical damage to potatoes, 10.1 per cent of the potatoes were mechanically damaged during digging operations; another 0.5 per cent, during picking; 5 per cent during field sacking; an additional 5.7 per cent in loading and hauling to the warehouse, and 5.2 per cent during bin filling. Thus, 26.4 per cent of the potatoes in the warehouse bins were damaged potatoes. Approximately 4.5 per cent of the potatoes were damaged seriously enough to be reduced in grade from U. S. No. 1 to U. S. No. 2 or lower. In addition, an average 15.6 per cent of the skin was removed from all the potatoes during harvesting operations.

Influence of Mechanical Damage on Storageability

In order to determine the effects of mechanical damage during harvesting operations on the storageability of potatoes, three samples obtained at each stage of the harvesting operations at each of two fields (Fields No. 3 and 4) were carefully placed in egg crates and stored at 36-40°, for six months At the end of this period, these lots were examined for bruises and decay.

The incidences of bruises and decay and the loss in weight of lots examined at harvest and in the stored lots are shown in table 4. The mean damage due to bruises in samples taken at various stages during harvest was 8.1 per cent. Potatoes in similar samples taken at the same time and stored for six months had an average of 33.7 per cent bruises at the end of the storage period.

This increase in bruises, amounting to 316 per cent, was primarily due to the fact that small bruises unnoticed at harvest time developed to some extent in storage so that they became distinguishable. That this was true is indicated by the following two facts: the lots examined at harvest contained an average of 5.9 per cent of bruises which reduced grade, whereas lots examined after six months' storage contained 9.2 per cent of such bruises. Likewise, 0.6 per cent of all the tubers stored for six months decayed in storage (Table 4). The greatest amount of decay (2 per cent) occurred in the lots which had been most severely bruised during harvesting operations (bin samples).

Despite the fact that some lots of potatoes contained considerably more damaged tubers than others, differences in shrinkage between these lots during storage is not apparent (Table 4). The average shrinkage of all lots was 4.9 per cent.

Influence of Warehouse Operations on Mechanical Damage

Mechanical damage to potatoes incurred during bin-to-sack operations was determined in nine warehouses. Two general methods of warehouse handling were observed. In the first, potatoes were scooped from the bins into a hopper from which they were elevated to the grading room, run over a grading table, and sacked without washing. In the second type of operation, some of the potatoes were flumed from bins to an elevator which conveyed them to a hopper from which they went through a washer

TABLE 4.—*Incidence of bruises on potatoes at harvest and of bruises, decay, and shrinkage in similar lots after six months' storage at 36-40° F.*[1]

Stage in harvest Operations	Potatoes Bruised[2]		Potatoes Decayed after Six Months' Storage[2]	Loss in Weight During Six Months' Storage
	At Harvest	After six Months' Storage		
	Per cent	Per cent	Per cent	Per cent
Behind digger	2.6	14.5	0.8	5.8
In picking basket	4.2	30.9	0.1	4.8
In field sack	8.0	30.4	0.2	4.2
On truck at warehouse	12.4	41.4	0.0	3.5
In bin at warehouse	13.3	51.2	2.0	6.4
Mean	8.1	33.7	0.6	4.9

[1]Data given are means of samples from two fields.
[2]Per cent by weight.

and then over a grader. Others were elevated dry to a hopper before going through the washer and over the grader.

The incidences of fresh bruises at various stages in dry handling of potatoes in five warehouses and in handling of washed potatoes in four warehouses are shown in table 5. An average of 1.0 per cent of the dry-graded potatoes incurred fresh damage in the bin due to rolling, *etc.* while the bin was being emptied. By the time the potatoes had been scooped into the hopper, 5.3 per cent had been damaged. After the potatoes had been elevated, run over the grader, and dropped into sacks the damage amounted to 11.8 per cent.

Although considerable variation between warehouses was evident, all

TABLE 5.—*Incidence of fresh bruises on dry-graded and washed potatoes at various stages of handling.*

Method of Handling	Stage in Handling	Potatoes with Fresh Bruises	Range in Fresh Bruises in Lots Examined
		Per cent	Per cent
Dry-graded[1]	In bin[3]	1.0	0- 3.7
	In hopper[4]	5.3	3.1- 7.1
	In sack[5]	11.8	7.9-21.5
L.S.D., 1 per cent level		3.3	....
Washed[2]	In bin[3]	0.0	....
	Entering washer	3.0	0- 6.9
	In sack[5]	2.9	0.6- 6.0
L.S.D., 1 per cent level		2.4	....

[1]Lots examined in 5 warehouses.
[2]Lots examined in 4 warehouses..
[3]After some potatoes had been removed.
[4]Prior to elevating and grading.
[5]After grading operation but with no potatoes graded out.

of them showed the same trend — increased bruising with increased handling. Most of the damage during dry handling was "slight." However, approximately one per cent of all the potatoes dry-graded were bruised seriously enough to be lowered in grade.

Mechanical damage to potatoes washed before grading in four warehouses is also shown in table 5. Approximately three per cent of the potatoes were bruised by the time they were sacked. Most of this damage occurred during fluming and elevating to the washer hopper. The washing and grading operations caused little, if any, injury to the potatoes. Approximately only one-tenth of one per cent of all the washed potatoes were bruised seriously enough to be lowered in grade.

Discussion

In the study reported here 33.8 per cent of the potatoes examined in the Red River Valley in 1949 were mechanically damaged during digging-to-packing operations. The amounts of injury resulting from various handling operations were as follows: digging, 10.1 per cent; picking into baskets, 0.5; dumping into field sacks, 4.9; loading truck and hauling to warehouse, 5.7; bin-filling, 5.2; and bin-to-shipping bag operations in the warehouse, 7.4 per cent. The last figure is an average of damage incurred during handling of washed and unwashed potatoes.

In terms of percentage distribution of the total injury, digging caused approximately 30 per cent of all the mechanical damage which occurred; picking, 2 per cent; sacking, 14; loading and hauling to warehouse, 17; bin filling, 15; and warehouse operations, 22 per cent. It is of interest to compare these data with those obtained in other studies conducted under somewhat different conditions. Such a comparison with studies made in Maine, Colorado, North Dakota and Oregon is shown in table 6. There are differences in the percentage distributions of injury obtained in the studies compared. However, these distributions are remarkably in agreement considering the differences in harvesting equipment, varieties, harvesting conditions, and handling methods undoubtedly involved in the various studies.

TABLE 6.—*Percentage distributions of total mechanical damage to potatoes due to various harvest operations obtained in five studios.*

Author and Reference Number	Year and State	Percentage of Total Damage to Potatoes Due to Indicated Operation					
		Digging	Picking	Placing in Field Sack or Barrel	Hauling to Warehouse	Filling Bin	Handling from Bin to Shipping Sack
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Schrumpf (6)	1933 Maine	20	2	9	....	21	48
Ferguson (2)	1946 Colorado	44	15	....	11	....	30
Schaffner (5)	1948 No. Dakota	28	17	....	16	39	....
Davis (1)	1952 Oregon	28	....	....	4	19	50
Present study	1949 Minn. and No. Dakota	30	2	14	17	15	22

Of the harvesting operations, digging and bin filling contribute over one-half of the mechanical damage incurred by the potatoes. Almost two-thirds of all the damage is done by the time the potatoes reach the warehouse bins. The remaining one-third is contributed by such warehouse operations as bin emptying, conveying, elevating, washing, grading, and sacking.

In addition to losses due to mechanical damage itself, however, damaged potatoes deteriorate in storage more readily than sound potatoes. In this study, samples of tubers which contained only 8.1 per cent of bruised potatoes at harvest contained 33.7 per cent bruised tubers at the end of six months' storage. Even more important is the fact that grade defects increased from 5.9 to 9.2 per cent during this period. Schrumpf (6) also found that at the end of 59 days' storage, grade defects had increased from 7.10 to 9.65 per cent due to the deterioration of slightly injured potatoes in storage.

The results of this survey point out the importance of the human factor in determining the amount of mechanical damage to potatoes during harvesting and handling operations. As the ranges in tables 1, 3, and 5 show, the incidence of damage to potatoes at various stages in harvesting varied greatly from farm to farm. This is shown most clearly in table 2, which gives the percentages of various types of mechanical damage on potatoes from each of the thirteen fields immediately after the potatoes had been placed in the storage bin. Total damage, excluding skinning, varied from 6.3 to 46.1 per cent. The differences in harvesting and handling equipment and field conditions in this survey were relatively small. Therefore, these great variations in damage are undoubtedly due to a great extent to differences in the way the harvesting and handling equipment was operated on the various farms.

Summary

1. The effect of harvesting operations on mechanical injury to potatoes was studied on thirteen farms in the Red River Valley area of Minnesota and North Dakota.

2. Field harvesting operations caused mechanical injury (cuts, bruises, and cracks) to 26.4 per cent of the potatoes handled. Digging injured 10.1 per cent; picking into baskets, 0.5; filling field sacks, 4.9; loading and hauling to warehouse, 5.7; and bin filling, 5.2 per cent of the potatoes.

3. In addition to the above types of mechanical damage, an average 15.6 per cent of the skin had been removed from potatoes by the time they reached the storage bins.

4. Of the 26.4 per cent total mechanical injury, excluding skinning, sustained by the potatoes during harvesting operations, 4.5 per cent were defects which were serious enough to score against grade.

5. Potato samples which contained 8.1 per cent mechanical damage when placed into storage contained 33.7 per cent mechanical damage after six months' storage at 36° - 40° F. During this period, bruises which decreased grade increased from 5.9 to 9.2 per cent.

6. The effect of warehouse operations on mechanical injury to potatoes was studied in five warehouses that dry-graded potatoes and in four which graded washed potatoes.

7. Operations in the dry-grading warehouses resulted in 11.8 per cent mechanical injury to potatoes. This injury was distributed as follows: emptying bins — 1.0 per cent, conveying and elevating to grader — 4.3, and grading and sacking — 6.5 per cent.

8. Operations in the warehouses which packed washed potatoes caused approximately 3.0 per cent mechanical injury, all of which was apparently caused by conveying and elevating the potatoes from the bin to the washer.

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A DIAGNOSTIC HOST FOR POTATO VIRUS A[1]

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The breeding of potato varieties for resistance to or immunity from virus A and other major potato diseases involves the testing of many clonal lines each year. The selections are planted in triplicate in the field and infested with virus A-infective aphids. Since current-season symptoms of virus A infection usually are not expressed in the field, and many potato seedlings are carriers of virus A, one tuber from each plant is harvested for planting in the greenhouse during the winter. Each tuber to be tested for the presence of virus A is planted adjacent to a healthy tuber of Green Mountain, and when the plants are 4-6 inches tall, the Green Mountain plant is grafted on to the plant to be tested. The Green Mountain plants grafted to a virus-A-infected plant usually show symptoms in 21-30 days. The relative percentage of resistance to virus A is recorded for each clonal line. Lines which did not contract the disease in the field are then grafted on virus-A-infected plants of potato seedling 41956 to determine the type of resistance inherent in each.

A suscept which would give a distinctive reaction to virus A in a relatively short time after inoculation, would eliminate the need for grafting to detect virus A in potato seedlings. Cockerham (1) and Kohler (2) reported the use of two selections of *Solanum demissum Lindl.* as local-lesion hosts for the detection of virus A. Plants of these two selections were tested for their usability for identifying these viruses in inoculated potato seedlings. Young plants of both varieties responded readily to infection but older plants were much less efficient indicators. Plants of the two varieties of *S demissum* have an indeterminate type of growth and require staking unless used as test plants for a relatively short period. Tubers of different potato seedlings vary in the length of their rest periods and although the tubers are treated to break this dormancy, they emerge over a considerable period of time. In order to have a continuous supply of test plants of the two varieties of *S. demissum*, several plantings *must* be made at weekly intervals prior to the emergence of the potato seedlings.

During routine testing of various Solanum species[3] for resistance to several potato viruses, one introduction of *S. demissum*, P.I. 175404, proved very sensitive to virus A. It developed small bluish-black, irregular-shaped lesions in 3-4 days on inoculated leaves (Figure 1). Because the plants of this introduction have a semi-determinate type of growth as shown in figure 2, and appeared to be suitable for the detection of virus A over an extended period, plants from this introduction were inoculated with several viruses to determine its suitability as a specific indicator for virus A.

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Photographs prepared by Otis Greeson.

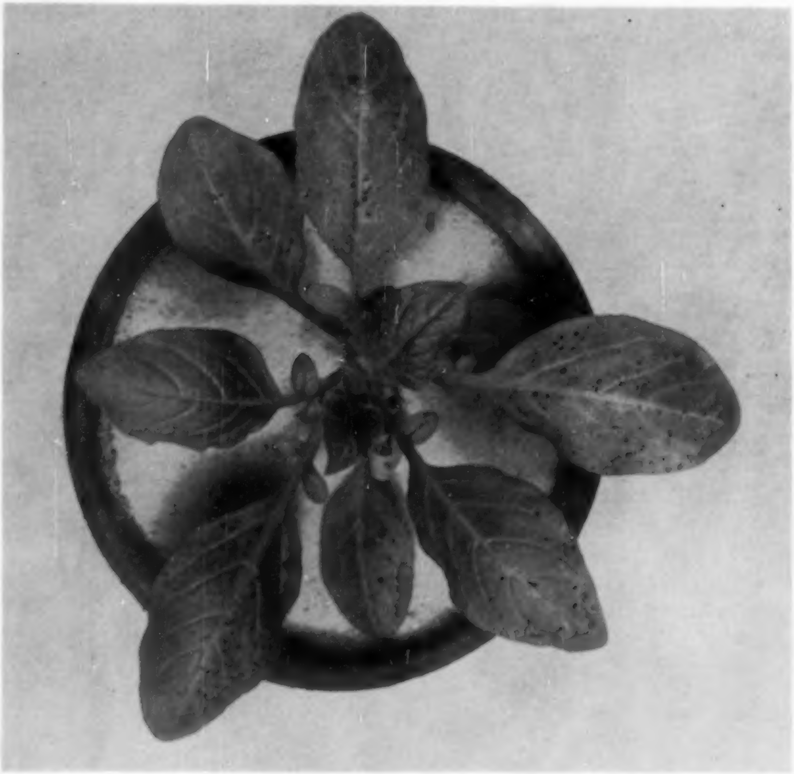

FIGURE 1.—Plant of *Solanum demissum* P. I. 175404 showing local lesions incited by virus A 6 days after inoculation by the rapid technique described on page 251.

MATERIAL AND METHODS

Unless it is otherwise stated, inoculations were made with sterile cheesecloth saturated with expressed juice from virus-infected plants of potato seedling 42898, seedling 41956, Green Mountain and Chippewa. Carborundum dust, 600 mesh, was applied lightly to the leaves just prior to the application of inoculum. Greenhouse temperatures were maintained at approximately 24°C.

RESULTS

Detection of virus A. Initially, all plants of *S. demissum* P.I. 175404 used in these studies were grown from tubers. Young plants in the 4- to 6-leaf stage were inoculated with expressed sap from virus-A-infected plants of potato seedling 41956 and Green Mountain. In 3 to 4 days small, bluish-black lesions characteristic of virus A infection developed on the

FIGURE 2.—Plant of *Solanum demissum* P.I. 175404 showing its semi-indeterminate growth and the number of leaves available for inoculation with virus A.

inoculated leaves. The only evidences of virus X infection were an occasional brownish sunken lesion about twice the size of those incited by virus A and some marginal burning with slight leaf chlorosis.

To determine the homozygosity of P.I. 175407 for reaction to virus A infection, 155 plants were grown from seed and inoculated with the virus. Characteristic necrotic lesions developed on the leaves of all inoculated plants.

Five plants of potato seedling 41956 were colonized with virus A-infective aphids and tested at weekly intervals to determine the relative

length of time after infestation that virus A could be transferred from them to P.I. 175404 plants. Local lesions appeared on inoculated leaves of P.I. 175404 28 days after aphid infestation of plants of seedling 41956, but not after 21 days.

Tubers of potato seedling 41956 systemically infected with virus A were planted to determine the stage of the infected plants at which virus A could be detected by inoculation to indicator plants. The infected plants were tested as soon as the first young leaves were unfolding and 7 and 14 days later. Initial inoculations to the indicator host produced three or four to each leaf. Succeeding inoculations gave a considerably greater number of lesions on each infected leaf (Figure 1).

A rapid method of inoculating plants with virus X was shown to be adaptable for use in detecting virus A in infected potato plants. A leaf was detached from a Virus A-infected plant and the petiole and leaflets were wrapped around one prong of a pair of large tweezers and rubbed vigorously on the blade of a sterile putty knife. The blade was then placed under the leaf to be inoculated and the leaf was rubbed lightly with the macerated leaf tissue remaining on the tweezers. After each inoculation the instruments were dipped in 95 per cent alcohol, flamed and cooled. Thirty-four such inoculations of plants of P.I. 175404 with virus A were successful.

Reaction of *S. demissum* P.I. 175404 to Other Potato Viruses

Virus X. Fifteen plants of P.I. 175404 were inoculated with a mild strain of virus X, 15 with a moderate one and 15 with a virulent one. The mild strain incited an occasional sunken, brownish, roughly circular lesion about twice the size of those characteristic of virus A infection. In 5-6 days, inoculated leaves became slightly chlorotic with slight marginal burning and abscissed shortly thereafter. The moderate and virulent strains produced lesions similar to those of the mild strain but more numerous. The number of lesions produced and the time of their appearance were directly proportional to the virulence of the strain of virus X. The virulent strain incited lesions in 2 days and the affected leaves abscissed the following day.

Virus Y. Plants of *S. demissum* P.I. 175404 developed a slight mottle about 20 days after inoculation with virus Y. This symptom was followed by moderate leaf curling and plant dwarfing.

Interveinal Mosaic Virus. Small elongated blister-like, distinctly yellow spots appeared on the leaves 18-25 days after inoculation with interveinal mosaic viruses. This symptom did not change over a 36-day period.

Plants of *S. demissum* P.I. 175404 inoculated with the viruses causing spindle tuber and leaf rolling mosaic failed to express symptoms of infection. Second-generation plants were apparently healthy.

Discussion and Summary

In 3-4 days plants of *S. demissum* P.I. 175404 inoculated with virus A expressed characteristic local lesions which are distinctively different from those incited by the other major potato viruses. The semi-indeterminate growth habit of the plants permits crowding in the greenhouse without materially affecting their suitability as indicator host plants. The plants may be grown in 3-inch pots and infected artificially

with virus A over a long period. Because of the relatively long narrow leaves, this host is adapted to the rapid inoculation technique developed for virus X inoculations. The large number of leaves produced by plants of P.I. 175404 enables the investigator to test several potato seedlings for virus A on one indicator plant. This host is being used extensively for the detection of virus A in inoculated potato seedlings in this laboratory.

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NOTE ON A VIRUS LATENT IN POTATO PLANTS[1]

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A recent attempt to prepare an antiserum against potato mild interveinal virus (4), gave evidence that potato sap often contains an antigen that behaves like a latent virus. In this attempt, each of two rabbits was given four intraperitoneal injections of clarified potato sap at weekly intervals. One rabbit received sap from plants of the virus X immune seedling 41956 infected with mild interveinal virus; and as a control the other rabbit was injected with sap from supposedly virus-free plants of the British potato variety, Epicure. Ten days after the fourth injection, the blood serum from each rabbit was tested at various dilutions against clarified potato sap. Not only was it found that an antiserum had been produced in both rabbits, but numerous precipitin tests failed to show any qualitative differences in the two antisera. Both antisera at dilutions of 1:160 or less caused specific precipitation when mixed with an equal volume of sap from plants of Epicure or 41956; and this was the case whether the plants were infected with mild interveinal virus or not. Neither antiserum caused precipitation in similar tests with sap from tobacco plants infected with either potato virus X or potato virus Y. Mechanical inoculations to suitable differential hosts likewise did not give any indication that either the 41956 or Epicure plants were infected with known strains of potato viruses A, X or Y.

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These two antisera also gave identical precipitin reactions with sap from *single* plants of 20 potato varieties. Positive reactions were obtained with the single plants of Albion, Arran Victory, Bliss Triumph, Canso, Green Mountain, Irish Cobbler, Katahdin, Kennebec, Majestic, President, and Southesk; whereas negative reactions were obtained with Chippewa, Craigs Defiance, Keswick, Russet Burbank, Sebago, Teton, Thorbecke, Up-to-Date, and Warba.

Similar tests with sap from 24 potato plants recently grown from true seed, however, gave only negative reactions. To test the hypothesis that the antigenic component was a latent virus, 12 of these 24 seedlings were mechanically inoculated with sap from an apparently healthy plant of seedling 41956 that had given positive reactions with the two antisera. Thirty-six days later, sap from the uninoculated upper leaves of the 24 seedlings was tested with the 41956 antiserum, the Epicure antiserum, and an antiserum prepared against potato virus X from tobacco. All of the 12 seedlings that had been inoculated gave positive reactions with both the 41956 and the Epicure antisera, but negative reaction with the potato virus X antiserum. In comparison, none of the 12 uninoculated seedlings gave reactions with any of the antisera. However, the inoculated seedlings had not developed any virus-like symptoms that distinguished them from the uninoculated controls.

This evidence seems sufficient to justify the conclusion that a latent virus other than those commonly known to infect potato, was present in the plants that gave positive reactions with the two antisera. This virus appears to be widespread, a point that should be kept in mind whenever potato sap is used to prepare antisera against other viruses.

A latent virus in potato plants has also been detected by serological methods in Holland (1, 5, 6) and in England (3). It also seems likely that a virus of this nature could be responsible for the virus-like particles found with the electron microscope in sap extracts of seedling 41956 (2).

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THE EFFECT OF DIFFERENT COMBINATIONS OF SOIL MOISTURE AND NITROGEN LEVELS ON EARLY PLANT DEVELOPMENT AND TUBER SET OF THE POTATO[1]

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The object of this research was to determine what effect different combinations of soil moisture and nitrogen levels would have upon tuber set and early development of the potato plant under field conditions such as are encountered by potato growers in upstate New York. We wished to know whether the number of tubers set or the earliness of tuber set could be influenced by soil moisture and nitrogen levels and if so whether such changes would be of benefit to the grower.

Irrigation studies conducted by Bradley and Pratt (2) showed that it was desirable to irrigate light textured soils before the available moisture dropped below 50 per cent. In some years a greater number of tubers were harvested under the higher moisture levels, whereas in others there were no significant differences. However, in most cases, rainfall kept the moisture level fairly high until the period of tuber set was well advanced.

Werner (4) found that nitrogen was very important in the tuberization process. He found that vegetative growth was favored by long days, high temperatures and an abundant supply of nitrogen. Early tuberization was induced with short days, low temperatures and a shortage of nitrogen. Maximum tuberization occurred with days of intermediate length, low temperatures and an abundant nitrogen supply.

Smith (3) reported that tuber set could occur over a period of several weeks and that some resorption of tubers occurred.

Materials and Methods

Two plantings of potatoes were made on a Dunkirk fine sandy loam at East Ithaca, New York during 1954. The first planting was made on June 9 of the variety Cherokee and the second planting was made in the same plots on August 8 after the first planting had been harvested. The Kennebec variety was used in the second planting because no more Cherokee seed was available. The equivalent of 250 pounds per acre of P_2O_5 and K_2O was applied in bands before each planting.

Plots containing eight plants spaced nine inches apart were used. Of these eight plants, the middle four were harvested as record plants and the soil about them was not disturbed until they were harvested. Soil moisture samples were taken from the vicinity of the four non-record plants which otherwise were treated the same as the record plants. The overall plot size was eight by three and one half feet. Ditches of about a foot in depth were dug around all plots to aid in carrying off the rainfall and to prevent lateral movement of moisture from plot to plot.

In order to control the moisture supply, light weight wood frames covered with polyethylene film were used to cover the plots where it was desired to keep off rainfall. The covers were made to fit into the

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ditches between the plots, thereby reducing the amount of wind that could get under them. These covers were put on only when there was danger of rainfall. All of the plots received sufficient rainfall to bring them to field capacity on September 15 when Hurricane Edna tore up many of the covers.

A factorial design was used, with four replications. The following moisture levels were used in both plantings:

1. Soil moisture level maintained above 75 per cent available moisture. All rainfall was allowed to fall on these plots.
2. Moisture level maintained above 50 per cent available. No rainfall allowed to fall on these plots.
3. Moisture level maintained above 25 per cent available. No rainfall allowed to fall on these plots.
4. Soil moisture level maintained above 5 per cent available. No rainfall allowed on these plots.
5. Rainfall only.

In the first planting, these moisture levels were used in all combinations with 150, 90 and 30 pounds of nitrogen per acre applied as ammonium nitrate. In the second planting these moisture levels were used in all combinations with 160, 80 and 0 pounds of nitrogen per acre applied as ammonium nitrate.

Soil samples were taken with a soil auger from the center of the rooting zone and oven dried at 105°C. for 12 hours. When the moisture samples indicated that the soil moisture was near the minimum level desired, sufficient water was added to bring the top foot of soil to field capacity. Because of the small size of the plots, the water was applied by means of sprinkling cans.

A number of check plants were planted and harvested periodically to determine when the first harvest should be made. It was desired to make the first harvest just when the first tubers were being formed. After the first harvest, three additional harvests were made at weekly intervals. Harvest dates for the first planting were July 12, July 19, July 26 and August 2; and for the second planting, September 7, 14, 21 and 28. To eliminate any possible bias, the plants were harvested in a definite order so that at each harvest date all the plants came from the same location within each plot. One plant was harvested from each plot at each harvest date.

Fresh weight of the plant top, dry weight of the plant top, the number of stolons and the number and weight of tubers were determined at each harvest date. The percentage of total organic and ammoniacal nitrogen was determined for the entire plant top on the dry weight basis using a modified Kjeldahl technique used by the Department of Pomology at Cornell University. This determination was made only for the first planting.

The data obtained were evaluated by the analysis of variance method for a 5 x 3 factorial design.

The average temperature during the first planting was 68.2°F. and the average temperature during the second planting was 61.8°F. Average daily solar radiation during planting one was 540 gm. cal. per square cm. and during planting two 322 gm. cal. per square cm. Table 1 shows the water usage in the various moisture treatments in the two plantings.

TABLE 1.—*Water usage in the two plantings.*

Minimum Percentage Available Moisture Level	Number of Times Minimum Percentage Was Reached		Average Weekly Water Usage	
	Planting I	II	Planting I	II
75	15	9	1.45	1.00
50	8	5	1.33	0.88
25	5	3	1.22	0.81
5	3	2	1.10	0.78
Rainfall only*	..	..	0.57	0.78

*Not total rainfall but computed water use by the plants receiving rainfall only.

RESULTS

Only the results on tuber set will be presented in graphic or tabular form. For complete data on the other measurements taken, see Bradley, Ph.D. thesis, Cornell University (1).

The 75 and 50 per cent moisture levels produced greater top weight and greater tuber weight than the lower levels of moisture with the spread becoming greater as the season progressed in both plantings. The plant tops from the 75 per cent moisture plots tended to run higher in percentage nitrogen than the other plots.

As the season progressed, the higher nitrogen levels tended to produce greater top weight. Plants from the higher nitrogen plots were also higher in percentage nitrogen. For the most part, there were no significant differences in tuber weight due to nitrogen level although the high and medium level plants were beginning to gain over the low-nitrogen plants in tuber weight at the last harvest in each planting. At the third harvest in planting two, the no-nitrogen plots had greater tuber weight than the other two nitrogen levels, probably due to the fact that nitrogen was limiting top growth and the manufactured food materials were being diverted largely to the tubers.

There were no significant differences in the number of stolons except at the first harvest date in the first planting when the higher moisture levels had a greater number. Most of the primary stolons were present before the beginning of tuber set.

.... Figure 1 shows the effect of the various moisture levels upon the number of tubers set in the two plantings. The higher moisture levels had set a greater number of tubers early in the season in both plantings. The plots subjected to rainfall only had not dropped below 60 per cent available soil moisture in the first planting until after the first harvest was made. The differences in the number of tubers set had disappeared by the second harvest date in the first planting and by the third harvest date in the second planting. Differences reappeared at the fourth harvest date in planting one as more tubers continued to be set in the 75 per cent moisture level plots and there appeared to be resorption of some tubers in the 5 per cent and rainfall only plots. No significant differences reappeared in planting two, probably due to the cooler weather which prevailed and the smaller differences in the amount of water used under the different treatments. The fact that all plots were saturated September

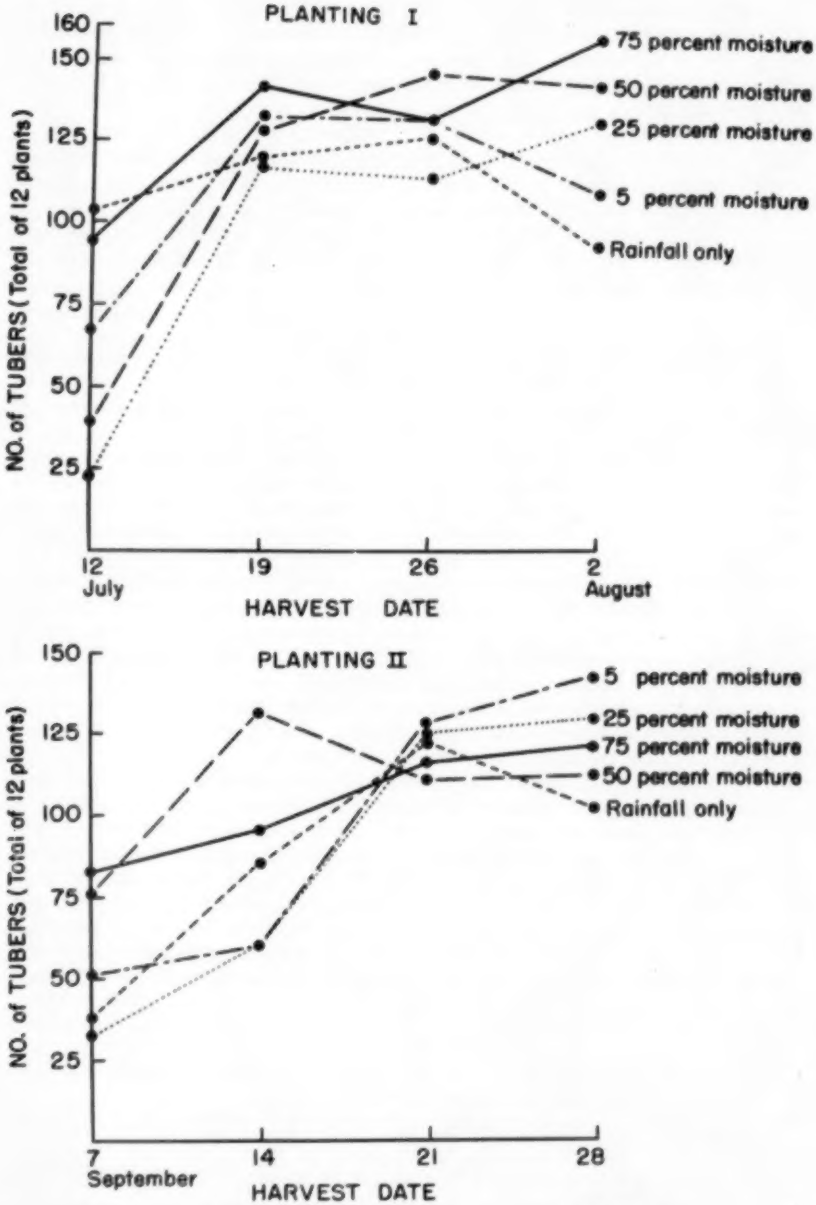

Figure 1 - THE EFFECT of AVAILABLE SOIL MOISTURE on TUBER SET.

15 may also have been a factor here. There was a good correlation (r = .871 in planting I and .690 in planting II) between top weight and tuber set at the first harvest date but this correlation became poorer as the season progressed (r = .280 in planting I and .281 in planting II at the 4th harvest date).

There was not much effect of nitrogen level upon the number of tubers set except that in the first planting the high and medium nitrogen levels had more tubers at the 4th harvest date than the low level. There were no significant interactions between moisture and nitrogen levels in the number of tubers set. There were some interactions between moisture and nitrogen level in top weight and tuber weight but these seemed to have no effect on tuber set.

Discussion and Summary

The importance of maintaining a high moisture level during the early growth and development of the potato was brought out clearly in this experiment. Maintaining a high moisture level resulted in better top growth, earlier tuber set and a greater weight of tubers.

The major effect of moisture level upon tuber set seemed to be upon the earliness of set rather than upon the total number of tubers set. This seemed to be closely related to the better top growth obtained under the high moisture levels. It is believed that a supply of carbohydrates is made available earlier in the season due to greater top growth and more leaf surface area for photosynthesis. It appears that the larger tops are able to provide sufficient food materials for good vegetative growth and still have a greater excess for tuberization.

There was not much effect of nitrogen level upon the number of tubers set. The 30 pounds of nitrogen added in the first planting was apparently enough for most of the growing period that followed. Differences in top weight and tuber weight and possibly also in the number of tubers probably would have appeared later in the season.

It would appear wise for growers to maintain a fairly high soil moisture level, especially early in the season. It is apparent that both the soil type and economic considerations must be taken into account in deciding upon the amount of irrigation equipment which a grower should have. It would appear that he should have enough equipment to keep the available soil moisture from dropping much below 50 per cent especially early in the season. To develop the best irrigation program for a particular situation would probably require a number of years experience there. Results such as those presented here should be of value in the development of such a program.

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FLAVOR TESTS ON POTATOES GROWN IN SOIL WHERE LINDANE WAS APPLIED TO CUCUMBERS[1]

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The extensive use of lindane in recent years for foliage treatments in commercial cucumber plantings in the Southeastern States has caused research workers to explore the possibility that effects of this insecticide may persist for more than one season. If the insecticide is one whose use is questionable insofar as it may impart off-flavor to certain vegetables, the problem of its cumulative retention in soils used for a crop-rotation schedule is also apparent.

Although of considerable value as a foliage application in the control of pickleworm and certain other insects on cucumbers without complaints of off-odor or off-flavor (6), similar use of lindane on potato plants has been followed by observations of off-flavors by Anderson and Reynolds (1) as well as in this laboratory.* Soil applications of lindane have been reported as adversely affecting, in varying degrees, the flavor of a number of other food crops (2, 3, 4) and, with root crops, flavor defects following soil applications of lindane or BHC have generally been more pronounced than with foliage applications.

Evidence has been accumulating too on the deleterious effect on flavor resulting from the use of lindane subsequent to a particular growing season. Results of taste tests conducted in this laboratory have shown that when lindane was applied to the soil at the rate of 1 pound per acre the year prior to that in which potatoes were grown, the treated samples were scored significantly lower than the untreated ones (4). Recent palatability panel evaluations have demonstrated an adverse effect on flavor of peanuts grown in soil previously planted with cotton that had been treated with 3.8 to 5.1 pounds per acre of gamma benzene hexachloride derived from 13 per cent gamma isomer grade of insecticide (7). Merrill's work on the residual effect of a single application of 3 pounds per acre of lindane for 3 growing seasons, on the other hand, did not indicate outstanding alteration of flavor (5).

Because potatoes grown in soil treated with lindane may have off-odors and off-flavors when cooked, the purpose of the taste tests reported here was to determine whether the application of lindane to fall cucumber plantings for the prevention of pickleworm damage would contaminate the soil sufficiently to affect the flavor of potatoes grown in these fields the following spring. Also, in an effort to ascertain if the undesirable effects of lindane would be more apparent after storage, samples were held 3 months at 55°F. for aditional flavor evaluation. The samples of potatoes were taken from field experiments carried out in Charleston, South Carolina and tested by the Human Nutrition Research Branch at the request of the Entomology Research Branch.

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*Unpublished data.

Soil Treatment Procedures

In the fall of 1950, eight weekly applications of either a 1-per cent lindane dust or of a spray composed of 1 pound of a 25-per cent lindane powder to each 100 gallons of water were made on cucumbers. Adequate pickleworm control resulted from the lindane treatment which was calculated to total 1¼ pounds per acre. Subsequently, in the spring of 1951, five varieties of early crop potatoes — Pontiac, Bliss Triumph, Irish Cobbler, Sebago, and Cherokee — were grown on these same plots. An untreated field on which the control samples were grown was located about 50 yards from the treated one, and did not receive lindane or other forms of benzene hexachloride.

Except for the Pontiac variety, potatoes from treated and untreated fields were harvested at 3 weekly intervals, May 23 and 30, and June 6 for palatability tests to discover if insecticide treatment effects varied with the maturity of potatoes. Samples for the Pontiac variety were available only from the second harvest date. Tubers from the first two harvestings were dug when most of the plants were immature and for purposes of this study were made a composite, Lot A. Those from the last harvesting were largely from more mature plants, designated Lot B, although because of drought there was little difference in tuber maturity at the three harvestings.

All lots of potatoes were stored several weeks after harvest in a cool, dark place until they were shipped to the Beltsville laboratories on June 15.

Procedures for Palatability Tests

To provide for uniform cooking samples, three to four tubers were selected for uniformity of shape and thickness and freedom from wireworm injury. Samples grown in untreated soil showed slightly more wireworm injury than those grown in treated soil. Eighteen samples representing all varieties were allotted for immediate taste testing. An equal number of samples, all varieties, were held for three months at 55°F. for flavor evaluation after storage. Tubers were desprouted once during the three months period to prolong storage life.

Potatoes were kept at room temperature during the week the cooking tests were being made. To prepare the potatoes for cooking, raw tubers were washed, dried, weighed, pared, and weighed again. Cooking was done on identical units, with voltage and wattage controlled. Each potato sample was cooked in 800 or 900 milliliters of boiling distilled water in covered enameledware pans of three-quart capacity. An iron-constantan thermocouple was threaded into one tuber from each cooking sample so that its junction recorded the internal temperature at the center of the tuber. The potatoes were cooked to an internal temperature of 205°F. (96°C.) as recorded by a potentiometer, drained into colanders, mashed through ricers, and stirred thirty strokes with a fork to insure well blended samples. Seasonings were not added. Individual portions of each sample were measured into coded white porcelain dishes and served to the judging panel while hot.

Palatability judging was done at individual tables in a room separate from that in which the samples were prepared. Food specialists of the

Human Nutrition Research staff, composing the palatability panel, were trained and experienced in recognizing characteristic natural odor and flavor as well as off-odor and off-flavor in a variety of foods grown in insecticide-treated soils.

Taste testing sessions were held in mid-morning and mid-afternoon of each day for one week. Samples were evaluated for flavor using a five to one scale — five representing the highest score, one the lowest. Panel members were asked to identify detectable off-flavors. At each session samples of one variety, two from treated and two from untreated plots, and from plants of both maturities were served to the judges in random order. After a ten-minute interval to allow for recovery of judges' taste acuity, a replication of the same test was given, with samples cooked and prepared separately from the first test and again served in random order. During the latter part of the week, tests were repeated on all varieties, making a total of four replications for each sample.

Judges' scores for flavor were analyzed statistically by analysis of variance to determine the significance of mean score differences within varieties in relation to previous crop treatment and to maturity of plants. The interaction of treatment and variety was also evaluated statistically.

Results

In a variety comparison of freshly harvested samples of either maturity from treated fields, (Table 1) flavor scores for Cherokee and Sebago potatoes were significantly higher than those assigned to comparable samples of Bliss Triumph, Irish Cobbler and Pontiac. Varietal differences were found to be non-significant from an appraisal of flavor scores of freshly harvested potatoes grown on untreated plots of either maturity.

Treatment effects on flavor differed with variety but tended to be more pronounced in the immature than in the mature tubers when freshly harvested. Flavor scores for the untreated samples rated, in general, higher than those grown in lindane-treated fields. This trend was significant for Irish Cobbler samples whether maturity scores for this variety were examined separately or in combination (Lots A and B) and for the immature Pontiac samples (Lot A). The effect of soil residue of lindane on the flavor of the freshly harvested Bliss Triumphs cannot be well defined, as significant differences between treated and untreated plots were obtained from flavor scores of immature samples (Lot A) and when maturities were combined (Lots A and B) but were not significant for the mature plants (Lot B). Sebago and Cherokee varieties did not exhibit significant effects due to growth in treated soils.

The group means of all varieties (freshly harvested) combined show that for immature tubers (Lot A) and for combined maturities (Lots A and B) flavor scores were significantly lower for samples from treated than from untreated plots; this result was valid regardless of whether Pontiacs of only one maturity were included in the comparison. Differences in scores were interpreted as indicative only of a trend, because of drought conditions during growth and the fact that time intervals between dates of digging were so short. Irish Cobblers from immature plants, however, when grown in treated plots scored significantly lower for flavor than those from mature plants. Differences, though not significant,

TABLE 1.—*Means of judges' scores*[1] *for flavor of potatoes grown in untreated fields and in fields previously used for growing cucumbers treated with lindane.*

Description of Sample	Bliss Triumph	Cherokee	Irish Cobbler	Sebago	Mean	Pontiac	Mean, all Varieties
Freshly harvested:							
Lot A (Immature)							
Untreated	4.5	4.6	4.5	4.2	4.4	4.4	4.4
Treated	3.4[3]	4.4	3.1[3]	4.2	3.8[3]	3.3[3]	3.7[3]
Lot B (Mature)							
Untreated	3.9	4.2	4.5	4.2	4.2	....	....
Treated	3.7	4.5	3.8[3]	4.4	4.1	....	....
Lots A & B Combined							
Untreated	4.2	4.4	4.5	4.2	4.3	4.4[2]	....
Treated	3.5[3]	4.4	3.4[3]	4.3	3.9[3]	3.3[2,3]	....
Stored 3 months at 55°C.:							
Lot A (Immature)							
Untreated	4.0	4.8	4.6	4.3	4.4	3.9	4.3
Treated	3.6	4.2	3.5[3]	3.8	3.8	3.4	3.7
Lot B (Mature)							
Untreated	3.7	4.0	4.4	4.3	4.1	....	....
Treated	3.2	4.5	3.3[3]	4.4	3.8	....	....
Lots A & B Combined							
Untreated	3.9	4.4	4.5	4.3	4.2	3.9[2]	....
Treated	3.4	4.4	3.4[3]	4.1	3.8	3.4[2]	....

[1]Means of 6 judges' scores, 4 replications; a score of 5 represents the best score, 1 the poorest.
[2]Immature only.
[3]Significantly different from untreated at the 5 per cent level.

were in the same direction for freshly harvested samples of Bliss Triumph, Cherokee and Sebago samples from treated fields. Conversely, from untreated plots freshly harvested mature Bliss Triumph potatoes scored significantly lower than immature samples of this variety, whereas the trend for Cherokee was the same but without significance.

Results of flavor evaluation tests upon completion of three months' storage were essentially similar to those of the freshly harvested samples, with highest scores for potatoes from treated plots again being obtained from the Cherokee and Sebago varieties. Irish Cobblers (both maturities) from treated fields were scored significantly lower than those from untreated fields, as were scored the freshly harvested potatoes of this variety. Flavor scores for Pontiac and Bliss Triumph followed the same pattern.

The similarity between the flavor ratings of the freshly harvested and stored samples provided no evidence that storage for three months significantly affected the flavor of any of the five varieties or was productive of the development of latent off-flavor. In support of this observation, notations of "musty" reported by the panel, were about equally numerous for the freshly harvested samples — 30 per cent of the total possible judgments for the stored and 28 per cent for the unstored.

Summary

Five varieties of potatoes, Bliss Triumph, Cherokee, Irish Cobbler, Pontiac and Sebago were evaluated when freshly harvested and after three months' storage at 55°F. to determine whether off-flavor effects resulted from production in fields used the previous year for growing cucumbers treated with lindane.

No significant off-flavor was detected in the Cherokee and Sebago varieties, whereas, flavor judgments for Bliss Triumph tended to be lower in the samples from treated than from untreated plots. Irish Cobblers of both maturities and Pontiacs from immature plants grown in treated plots gave tubers scoring significantly lower for flavor than those grown in untreated plots when freshly harvested and also after three months' storage at 55°F. Samples from all varieties grown without treatment did not differ significantly in either harvest whether stored or unstored.

A comparison of treated samples on a maturity basis showed that flavor scores for immature plants were lower than those from mature plants. Differences based on maturity are indicative only of a trend because of drought conditions during growth and the short time intervals between harvest dates.

The preponderance of reports of "musty" accompanied the significantly low scoring treated lots of Bliss Triumph and Irish Cobler (both maturities) and of Pontiac (one maturity) which would appear to substantiate the finding of off-flavor for these lots.

An appraisal of the scores for both freshly harvested samples and those stored for three months at 55°F. did not reveal significant differences in the scores caused by storage.

It may logically be concluded from these results together with the findings of other workers that even foliage applications of lindane may prove to be a potential source of off-flavor both in a current season's crop and to those subsequently grown with the same treatments. An endeavor to develop insecticide substances which may be used indefinitely without lessening flavor quality seems expedient.

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Acknowledgment

The authors gratefully acknowledge the assistance of W. J. Reid, Jr., and F. P. Cuthbert, Jr., Entomology Research Branch for providing the potatoes and of Elsie F. Dochterman and Albert B. Parks, Human Nutrition Research Branch, for statistical analysis of the data.

HOW TO GROW AND STORE POTATOES FOR THE CHIP INDUSTRY[1]

ORA SMITH[2]

Are you taking advantage of the tremendous demand of the potato chip industry for increasing quantities of good processing potatoes? Did you get your share of the 32 million bushels sales that were made to this expanding industry in 1954? Potato chips are made in every state in the country and are distributed and consumed in practically every settlement regardless of size. It is a good steady outlet for potatoes and comprises one-ninth of all potatoes eaten as human food. In recent years it is increasing 3 to 3.5 million bushels annually.

One of the most important duties of a potato chip processor is the selection of his raw materials and of the raw materials which he uses the potato is the most important. Quality of the raw stock varies considerably between varieties and within the variety when grown under different soil and environmental conditions. It also is tremendously affected by temperature during storage and transit. If you, as a grower, understand just what a processor must have and why he must have it and attempt to supply it, you will be in a better position to sell and to bargain for a sale than those who make no attempt to fill these requirements. In many instances, the potatoes which a processor receives are absolutely worthless to him for processing no matter how good they look on the exterior. A processor must be supplied with potatoes that will process into desirable light colored chips and be of relatively low oil content. The yield of chips from the potatoes should be high.

Growing and handling potatoes by routine methods for supplying the fresh market trade may not be the best for the chipping industry. Practically everything a grower does in producing a crop of potatoes has some effect on the quality of chips or yield of chips made from them.

The number one requirement of a potato is that it process into a light color chip. People "eat with their eyes" and since the consumers' choice is predominantly for an attractive light golden brown color chip, the processor finds his sales decreasing when he is unable to produce that quality.

Some of the basic factors on which a chipper should make his choice of potatoes are: (1) grade, (2) variety, (3) specific gravity, (4) maturity and (5) the storage conditions preceding purchase. Various cultural factors such as irrigation, fertilizer program, spray program for the control of insects and diseases, method of vine killing and others will also determine whether or not the potatoes are desirable for chipping. All of these will be discussed in this article.

(1) Grade. The choice of the particular grade of potato varies considerably from processor to processor. It is not the most important thing to be considered in his choice since it concerns largely the exterior appearance of the potato. Most processors are not as critical of the outward appearance of the potato as the housewife is. He is, however,

[1]Accepted for publication March 31, 1955.
[2]Deparment of Vegetable Crops, Cornell University, Ithaca, N. Y. Paper No. 389.

interested in the size of tubers, amount of defects, rots, second growth, growth cracks, greened tubers, *etc.* They need not be washed. The amount of defects and also the size of tubers determine the loss in peeling and hand trimming. This is important. Some growers consistently buy nothing but U.S. 1 grade, others buy commercial grade and some think that field run potatoes are the best buy. Some may purchase one grade part of the time and another grade for another part of the year depending upon price, quality and performance and what appears to be the best bargain. But keep in mind—no matter how good they look on the outside they must make crisp, tasty chips of light golden brown color. If they don't meet this standard they are worth little or nothing to the processor—unless he can't get anything bettter

(2) Variety. What is desired in a variety?

Above all it must process into a chip of light color, not only a portion of the year but during the entire storage season. Every slice and all portions of each slice preferably should be of uniform light golden color. Many potatoes will produce chips which are light at the apical end and dark at the basal end. These are undesirable and must be picked out and thrown away or if left in, they lower the quality of the product. A potato may boil, bake or mash to a beautiful snow white and yet be worthless to the chipper because it fries too dark. The chemical systems in the potato which result in these discolorations are entirely different in their reactions and, therefore, different treatments are necessary to prevent them.

A variety should be of high specific gravity so that it will result in a high yield of chips of relatively low oil content. This is very important to the processor and to a great degree it determines the extent of his profits. The higher the specific gravity of potatoes the lower the oil content of the chips. Oily chips are not highly desirable and are costly to produce because of the cost of oil. The chips also should be crisp, of good flavor, no blistering and with no defects as a result of hollow heart, vascular discoloration, stem end browning, *etc.*

There is no one variety which meets all of these requirements at all times. Growing conditions and production areas influence these factors so that a variety may perform well at one time of the year but not at another or from one growing area but not from another. So choosing by variety alone is not sufficient. There can be as much difference between the same variety grown under different conditions or in different areas as there is between any two good varieties.

Considering all of these factors the following varieties are recommended for chips when they are grown in the areas to which they are well adapted: Russet Rural, Smooth Rural, Russet Burbank, Irish Cobbler, Kennebec, Sebago, Katahdin and Cherokee. Chippewa produces chips of acceptable color but usually the specific gravity is so low that yield of chips is low and oil content is high. Of the potatoes that are not stored but are processed in the spring and early summer the White Rose from California and Sebagoes from the southern states are acceptable.

(3) Specific Gravity of Potatoes. This is an excellent tool or yardstick to determine the processing quality of the potatoes which the grower has for sale. As mentioned earlier it determines the yield and oil content of the chips and to some degree it also affects chip color. It should be high,

indicating that the potatoes are low in water content. Every grower or dealer who is interested in selling to the potato chip trade should have a "potato hygrometer," an instrument which quickly and accurately determines the specific gravity of any lot of potatoes. These instruments are manufactured and sold by the National Potato Chip Institute, 1360 Hanna Building, Cleveland 15, Ohio.

The factors which affect specific gravity of potatoes during the growing season will be discussed later in this article.

(4) Maturity of Potatoes. Maturity is highly desirable in potatoes for chipping. Immature potatoes are of low specific gravity and hence result in low yields of chips with a high oil content. Color of chips from immature potatoes which are stored is likely to be undesirably darker than chips from mature potatoes. Mature potatoes are also more quickly and satisfactorily reconditioned for chip making after storage than are less mature tubers. The chemical composition of mature and immature potatoes is considerably different and in favor of the mature tubers. Immature potatoes such as those harvested in southern California and in the southern states process to a desirable color if they are fried soon after harvest and are not subjected to cool temperatures during transit.

Maturity can be obtained best by planting early as possible, harvesting late and by killing potato vines fairly slowly so that food manufactured in the leaves can be translocated to the tubers. A fairly low nitrogen and potash supply, high phosphorus supply and not too much rainfall or irrigation also will hasten maturity.

Factors Affecting Maturity, and Specific Gravity of Potatoes and Color of Potato Chips

Specific gravity of potatoes and color of potato chips depend on the chemical composition of the tubers. The chemical composition is influenced by a number of factors which are discussed below.

(1) Variety. This topic has been discussed earlier in this paper. Some varieties, such as Green Mountain, are never used for potato chips because their chemical composition is such that chips made from them are always too dark. Because of this they are not processed although their specific gravity is consistently high. A good choice of a variety would be from one or more of the eight varieties mentioned earlier.

(2) Soil Type. Type of soil in which potatoes are grown may affect specific gravity of tubers because of its moisture content and consequent temperature. For instance, a sandy soil would be of lower moisture content than a loam or clay loam soil. In a wet season this could be an advantage and result in potatoes of higher specific gravity. In a dry season, however, it may result in lower yields but the potatoes might still be high in specific gravity unless the season was very hot. A soil high in moisture content will usually be several degrees cooler than a similar soil of low moisture content. This cooler soil may result in high specific gravity tubers because less food is lost from the potatoes by respiration.

As a general rule, potatoes grown in muck soil are of lower specific gravity than those grown in mineral soil in the same area.

(3) Date of Planting is very important in determining specific gravity and maturity of potatoes. Early planting lengthens the season of growth and results in greater maturity at harvest time than from any later planting.

(4) Date of Emergence of Plants is very important since that determines the time at which the plants start to manufacture their own food. This also affects maturity and specific gravity of the tubers. If the soil is dry or cold after planting, the time of germination will be delayed and the growing season therefore, shortened. Hence, the date of emergence actually is more important than date of planting for determining specific gravity and maturity of the tubers.

(5) Kind and Amount of Fertilizer Applied also affects maturity and specific gravity of the tubers. High nitrogen applications result in prolonged growth of the plant and delayed maturity. High potash applications also tend to prolong growth; phosphorus promotes maturity. Hence it is best to apply no more complete fertilizer than is necessary for satisfactory yields.

(6) Rainfall, Irrigation and Soil Moisture affect the quality of potatoes for processing. Up to a certain point, of course, these factors are necessary for growth of the potato plant. Usually, however, maturity is promoted and specific gravity is higher when potatoes have been grown in low to medium soil moisture than at high soil moisture. Therefore, it is best not to irrigate too heavily or too late in the season unless temperatures are very high. As mentioned earlier, a dry soil will reach a higher temperature than the same soil when moist and in hot seasons this may result in lower specific gravity tubers because of greater loss of food by respiration.

(7) Spraying for Control of Diseases and Insects also has an effect on the quality of potatoes for chipping. In most areas it is necessary for the growers to spray or dust with Bordeaux mixture, insoluble coppers or organic fungicides such as Dithane for the control of fungus diseases, especially early blight and late blight. There is no evidence that this procedure is harmful to potato chipping quality except that it delays maturity of the plants. It is a necessary evil as far as potato processing quality is concerned.

For insect control DDT is most extensively used. Because of its successful control of most common foliage insects, it prolongs growth, delays maturity and, in most instances, necessitates vine killing. It is recommended that DDT be omitted from the fungicide spray during the last 2 or 3 applications. This may result in more mature potatoes than if DDT applications were made later in the season.

(8) Killing Potato Vines. Before the days of DDT it was not necessary to kill potato vines for table stock potatoes; insect injury did it for us. While the insects were slowly killing the plants there was translocation of manufactured food from the tops of the plant to the tubers. This food (sugar) was converted to starch resulting in high specific gravity potatoes. When our modern rapid methods of vine killing are employed, there is little or no opportunity of transfer of food from the tops to the tubers. Lower specific gravity and different chemical composition of the tubers result. It is best therefore, to kill potato vines slowly if possible, or to

kill them as late as possible. All of our experiments show that specific gravity of tubers was higher from plants killed slowly (such as by chemical sprays) than by rotobeater if both were done on the same date.

(9) *Date of Harvest.* In order to get as mature a potato as possible, harvest should be delayed as long as you can without subjecting the potatoes to too low a temperature. Potatoes should not be chilled or allowed to frost in the field before or during digging or in transit to the storage. Undoubtedly some potatoes are ruined for use as chipping potatoes by exposure to temperatures under 40°F. before they reach the storage. It is very important to have a record of the day and night temperatures which prevailed in the field during the last 2 weeks of growth before harvest and during harvesting operations.

Additional Factors of Importance

The grower should know all he can about the following subjects and be able to give the information to the processor so that he can follow it up in the processing plant with performance of the potatoes as chips.

(1) Were Sprout Inhibitors Applied in the Field?

It is necessary to store potatoes at 40°F. or lower to prevent sprouting. However, storage at these low temperatures results in accumulation of sugars and other chemical changes in the tubers which result in dark colored chips. This necessitates long, costly periods of reconditioning at high temperatures to obtain desirable color. In some seasons and with some varieties and with immature potatoes this sometimes cannot be accomplished at all or within a feasible length of time. It would be desirable to have potatoes treated so that they could be held at 45° to 50°F. or higher for some time without sprouting or with few short sprouts.

Spray applications with maleic hydrazide (MH 40) to plants in the field late in the season have greatly reduced sprout growth of potatoes when stored subsequently at 50°F. This should be applied usually in August about the time that a few lower leaves start to turn yellow and die. A rate of 7 pounds MH 40 per acre is recommended. The material costs about $15.00 per acre. This application should not be made to potatoes which are to be used for seed for it may keep them from growing even after they are planted. Several other chemicals and methods for preventing sprout growth are available but they are not yet recommended for use because of lack of clearance with the FDA or because of excessive cost or for other reasons. (Check with your local FDA on use of MH after July 22, 1955.)

The grower should keep a record of any sprout inhibitor used, its rate and date of application, *etc.*, so that he can supply this information to the processor.

(2) Prevalence of Late Blight or Other Diseases Affecting Tubers

Growers should record the dates of spray or dust applications of fungicides and the material which was used. If any blight, *etc.*, is present it should be noted that potatoes from these areas should be stored separately and not be offered for sale to processors.

(3) Potatoes Should Be Handled Carefully

A great amount of damage to potatoes often results during harvesting. An excellent crop can be ruined by bruising, skinning and cutting tubers during digging, picking up, transporting and unloading into storage. Roughly handled tubers result in poorer keeping quality and extra work and loss at the trimming table.

(4) Conditions During Transit

Potatoes should be held between 45° and 75°F. during transit. If held at too low temperatures or if iced too much in transit they may result in chips that are too dark. Temperatures above 75°F. for very long periods of time, especially in fairly tight areas may result in blackheart. Ventilation in cars or trucks during shipment is considered highly desirable.

(5) Conditions During Storage

Farm storages or other storage structures adapted to the storage of potatoes for the fresh market are usually not the best for chip potatoes. Control of temperature and ventilation or air movement is much more important for potatoes to be made into chips. Automatic controls are highly desirable.

The building should be well insulated. There should be exhaust fans in the roof or in the peak of a gable for good exchange of air.

In general, bins should be smaller than for table stock potatoes, not more than 10 feet wide and the potatoes 10 to 14 feet deep. In order to keep potatoes from being in an area of poor air circulation, it is suggested that the lower part of the bin side walls be tapered toward the center of the bin floor. With air ducts 24 inches wide and 16 inches deep in the floor of the center of the bin running from front to back, air movement from the duct up through the pile is assured. Therefore the pile is warmed up or cooled off as rapidly as desired and excess moisture is removed. With constantly recirculated air there are no dead air spots nor any temperature stratification in the bins. Air is taken from the ceiling of the room and forced through the duct system below the bin floors. Warm air when needed is best brought in at 70°-80°F. from a heated room adjoining the storage by the use of a thermostat controlling a damper motor. A cooling action thermostat and time clock operate an exhaust air system which brings in outside air when lower temperatures or an air change is desired. An excellent publication on "White Potato Storage for New Jersey, Long Island and Southeastern Pennsylvania", Marketing Research Report No. 70 may be obtained by writing to United States Department of Agriculture, Agricultural Marketing Service, Washington 25, D. C.

Performance of the Potatoes in the Processing Plant

The pay-off on all the above mentioned information is, of course, the quality of the chips which are made from these potatoes.

The grower, after following the best known methods for producing and handling potatoes for processing should have a good record of how the crop was produced and stored. This information should then be given to the processor so that he can relate this to the quality of chips from these potatoes. If color of chips, for instance, is good in one shipment and unsatisfactory in another, the chances for finding what caused this

difference is much greater if the processor has all the information on these two lots as listed above. If he does not have this information and cannot get it from the grower, he may not be able to use this second lot. If he had the necessary records it might be possible to alter storage temperature or some other factor so that the potatoes would be of use to him.

After several seasons of such records as called for above, the processor and the grower will have a better idea which procedures to continue and which to avoid in order to be assured of satisfactory potatoes for chipping.

Suggestions for Growing Potatoes for the Chip Industry

1. Grow varieties which produce light colored chips, such as Russet Rural, Smooth Rural, Russet Burbank, Irish Cobbler, Kennebec, Sebago, Katahdin, Cherokee and, where they are not to be stored, the White Rose.

2. Plant as early as possible.

3. Do not overfertilize. Use enough fertilizer to assure a good yield. Keep the nitrogen and potash portions of the fertilizer as low as possible but still high enough to give good yields. Use of sulfate of potash instead of muriate of potash (KCl) in the fertilizer will usually result in higher specific gravity potatoes.

4. Do not over-irrigate or irrigate late in the growing season. High soil moisture content often results in lower specific gravity potatoes.

5. Omit DDT from the fungicide sprays during the last 2 or 3 applications. This tends to allow plants to mature and produce tubers of higher specific gravity.

6. Kill potato vines with chemicals or in some way (rather than rotobeat) that allows translocation of food from the tops to the tubers thus resulting in potatoes of higher specific gravity.

7. Harvest as late as possible but without subjecting potatoes to temperatures under 40°F. either before, during or after harvest.

8. Handle potatoes carefully at all times.

9. Grade potatoes to meet U.S. #1 standards.

PROGRAM OF THE 39th ANNUAL MEETING OF THE POTATO ASSOCIATION OF AMERICA

September 6, 7, 8, 1955

Michigan State University, East Lansing, Mich.

Tuesday Morning, September 6, 1955

Room 102, Conservation Building, 9:00 A.M.

Session 1

C. W. FRUTCHEY, **Presiding**

Problems in Potato Seed Certification

9:00 — 1. **NEW VARIETIES: Resistance to Diseases,** F. J. STEVENSON, Department of Agriculture, Beltsville, Md., **Testing New Varieties,** H. O. WERNER, University of Nebraska, Lincoln, Nebr.

CONTROLLING VIRUS DISEASES: Mechanical Transmission, R. H. LARSON, University of Wisconsin, Madison, Wis.; **Producing Virus X-free Seed,** JAMES MUNRO, Department of Agriculture, Fredericton, New Brunswick, Canada; **Experiments with X-free Seed in North Dakota,** W. G. HOYMAN, Horticultural Crops Section, U.S.D.A., State College Station, Fargo, N. D.

BACTERIAL DISEASES: Control of Bacterial Diseases with Antibiotics, REINER BONDE, University of Maine, Orono, Me.; **Varieties that Act as Carriers of Ring Rot,** M. A. FELTON, Certification Association of Nebraska, Alliance, Nebr.

SPROUT INHIBITORS: Maleic Hydrazide, JAMES KENNEDY, S. Kennedy & Sons, Clear Lake, Iowa.

IRRADIATION: DONALD R. ISLEIB, Michigan State University, East Lansing, Mich.

Tuesday Afternoon, September 6

Room 102, Conservation Building, 1:30 P.M.

Session 2

A. E. MERCKER, **Presiding**

Potato Processing and Chipping

1:30 — 1. **Equipment to Measure the Resistance of Potatoes to Pressure, Skinning, and Impact Bruising. (Illustrated 2 x 2).** RICHARD L. WITZ, North Dakota Agricultural College, Fargo, N. D.

1:50 — 2. **Effect of K_2O Fertilizer upon Chipping Quality of Potatoes. (Illustrated 2 x 2).** TOM EASTWOOD, Wise Potato Chip Company, Berwick, Penn.

2:05 — 3. **Effect of N Fertilizer upon Chipping Quality of Potatoes. (Illustrated 2 x 2).** TOM EASTWOOD, Wise Potato Chip Company, Berwick, Penn.

2:20 — 4. **Effect of Rate and Source of Potash on Specific Gravity of Potatoes in the Northeast.** ARTHUR HAWKINS, University of Connecticut, Storrs, Conn.

2:35 — 5. **The Influence of Variety on the Specific Gravity-Mealiness Relationship of Potatoes.** ALLEN E. SCHARK, C. E. PETERSON, and FRANCES A. CARLIN, Iowa State College, Ames, Iowa.

2:50 — 6. **Relationship of Starch Grain Size of Potato Quality. (Illustrated 2 x 2).** K. N. SHARMA and N. R. THOMPSON, Michigan State University, East Lansing, Mich.

3:05 — 7. **Microscopic Observations of Starch Grains in Relation to Maturity and Quality of Potatoes and Lima Beans. (Illustrated 3¼ x 4).** D. K. SALUNKHE and L. H. POLLARD, Utah State Agricultural College, Logan, Utah.

3:25 — 8. **Model System Studies of Potato Chip Color. (Illustrated 2 x 2).** ORA SMITH and R. S. SHALLENBERGER, Cornell University, Ithaca, N. Y.

3:40 — 9. **The Browning Reaction in Potato Chips, (Illustrated 2 x 2).** R. S. SHALLENBERGER and ORA SMITH, Cornell University, Ithaca, N. Y.

3:55 — 10. **Use of Plant Tissue Tests in Potato Nutrition Studies. (Illustrated 2 x 2).** WALTER SAIDAK and ORA SMITH, Cornell University, Ithaca, N. Y.

4:05 — 11. **Potato Flakes. A New Form of Dehydrated Mashed Potatoes. Review of Pilot-plant Process. (Illustrated 3¼ x 4).** MILES J. WILLARD, JR., JAMES CORDING, JR., RODERICK K. ESKEW, PAUL W. EDWARDS and JOHN F. SULLIVAN, United States Department of Agriculture, Eastern Regional Research Laboratory, Agricultural Research Service, Mermaid Lane, Philadelphia 18, Pa.

Tuesday Evening, September 6

6:00 **Annual Banquet, Room 21, Union Building**

Presentation of 1955 Honorary Life Members

Wednesday Morning, September 7

Room 102, Conservation Building, 9:00 A.M.

Session 3

W. G. HOYMAN, **Presiding**

Potato Diseases

9:00 — 1. **Survival of *Streptomyces scabies* in Peat Soil Planted with Various Crops. (Illustrated 2 x 2).** W. J. HOOKER, Iowa State College, Ames, Iowa.

9:10 — 2. **The Hindenburg Russet Character in Relation to Scab. (Illustrated 2 x 2).** G. H. RIEMAN, University of Wisconsin, Madison, Wis.

9:25 — 3. **Chromatographic Studies of Leaf-Roll Virus.** C. W. McANELLY, Colorado A & M College, Fort Collins, Colo.

9:40 — 4. **Use of 2,3,5 Tetrazolium Chloride to Detect Virus Infection in the Potato. (Illustrated 2 x 2).** R. E. WEBB, JOHN APEL, and JOHN MITCHELL, Horticultural Crops Section, U.S.D.A., Beltsville, Md.

9:50 — 5. **Leaf-Roll Resistance in *Solanum tuberosum*. (Illustrated 2 x 2).** R. E. WEBB, R. V. AKELEY, and F. J. STEVENSON, Horticultural Crops Section, U.S.D.A., Beltsville, Md.

10:05 — 6. **Selection of Leaf-Roll Resistant Potatoes in the Seedling Stage. (Illustrated 2 x 2).** W. J. HOOKER, C. E. PETERSON, and N. R. THOMPSON, Iowa State College, Ames, Iowa and Michigan State University, East Lansing, Mich.

10:20 — 7. **The Preservation of Potato Viruses X and Y by Freezing. (Illustrated 2 x 2).** WM. G. HOYMAN, Horticultural Crops Section, U.S.D.A., North Dakota Agricultural Experiment Station and North Dakota State Seed Department, Fargo, N. D.

10:35 — 8. **A Large Late Blight Chamber with Automatic Temperature and Humidity Controls. (Illustrated 2 x 2).** WM. G. HOYMAN, Horticultural Crops Section, U.S.D.A., North Dakota Agricultural Experiment Station and North Dakota State Seed Department, Fargo, N. D.

10:50 — 9. **The Value of Seed Treatment as a Control for Fusarium Storage Rot of Potatoes. (Illustrated 2 x 2).** G. W. AYERS, Laboratory of Plant Pathology, Charlottetown, P.E.I., Canada.

11:05 — 10. **The Resistance of Potato Varieties to Storage Rot Decay Caused by *Fusarium sambucinum* f6 and *Fusarium coeruleum*. (Illustrated 2 x 2).** G. W. AYERS, Laboratory of Plant Pathology, Charlottetown, P.E.I., Canada.

Wednesday Afternoon, September 7

Room 102, Conservation Building, 1:30 P.M.

Session 4

G. W. AYERS, **Presiding**

Potato Genetics and Culture

1:30 — 1. **Irish Potato Pollen Storage. (Illustrated 2 x 2).** J. R. KING, Louisiana State University, Baton Rouge, La.

1:50 — 2. **Hybridization of Certain Tuber-bearing *Solanum* Species. (Illustrated 2 x 2).** R. W. HOUGAS, R. W. POSS, and K. I. BEAMISH, University of Wisconsin, Madison, Wis.

2:05 — 3. **The Use of Colchicine Induced Tetraploids in Potato Breeding. (Illustrated 2 x 2).** K. I. BEAMISH and JEAN SNEIKAL, University of Wisconsin, Madison, Wis.

2:20 — 4. **Inducing and Maintaining Polyploids of *Solanum polyadenium*. (Illustrated 2 x 2).** LEO A. DIONNE, Field Crop Insect Laboratory, Fredericton, N.B., Canada.

2:35 — 5. **Foliar Application of Urea as a Method of Supplying Nitrogen for Potatoes.** ARTHUR HAWKINS, University of Connecticut, Storrs, Conn.

2:50 — 6. **The Effect of Level of Nitrogen Fertilization on the Yield and Quality of the Russet Burbank Potato When Grown in Wisconsin. (Illustrated 2 x 2).** J. A. SCHOENEMANN, University of Wisconsin, Madison, Wis.

3:05 — 7. **Efficiency of Various Methods of Washing Red River Valley Potatoes. (Illustrated 2 x 2).** J. M. LUTZ, HERBERT FINDLEN, and JOHN HANSEN, Biological Sciences Branch, U.S.D.A., 641 Washington Street, New York 14, N. Y.

3:20 — 8. **A Quarter Century of Potato Variety Testing in Rhode Island. (Illustrated 2 x 2).** J. E. SHEEHAN and T. E. ODLAND, University of Rhode Island, Kingston, R. I.

3:35 — 9. **Varietal Characteristics Associated with Susceptibility to Internal Necrosis of the Potato Tuber.** ARTHUR WOLCOTT and N. K. ELLIS, Purdue University, Lafayette, Ind.

3:50 — 10. **Management Factors Influencing the Germination of Potato Seed.** H. O. WERNER, University of Nebraska, Lincoln, Nebr.

4:00 — 11. **Further Observations of Some Anomalous Morphology Development with the Potato Plant. (Illustrated 2 x 2).** H. O. WERNER, University of Nebraska, Lincoln, Nebr.

4:10 — 12. **Progress Report of Storage Studies at the Scotts Bluff Station. (Illustrated 2 x 2).** H. O. WERNER and LIONEL HARRIS, University of Nebraska, Lincoln, Nebr.

Thursday Morning, September 8

Business Meeting

Room 102, Conservation Building, 9:00 A.M.

ARTHUR HAWKINS, **President, Presiding**

POTATO LATE BLIGHT FORECASTING SERVICE SET UP IN AROOSTOOK COUNTY, MAINE

An "on-the-spot" late blight warning service, established in Aroostook County, Me., this year, is expected to help prevent extensive future losses on the Maine potato crop to this disease, the U. S. Department of Agriculture said today.

Instituted by the U. S. Department of Agriculture and the Maine Agricultural Experiment Station, this service represents an extension of the Department's cooperative Plant Disease Warning Service, which for seven years has been providing this nation's growers of fruits, vegetables, and tobacco with advance information on such destructive diseases as late blight of potato and tomatoes; downy mildew of watermelons, cantaloupes and lima beans; and blue mold of tobacco.

Establishment of this "localized" warning in Aroostook county will help guarantee an annual crop from one of the nation's biggest potato producing areas. In past years, late blight has caused losses of as many as 4,700,000 bushels — 10 per cent of the total potato crop of Aroostook county. As a result of a late blight epidemic in Ireland in 1845 more than a million people died of starvation and another 1½ million were forced to emigrate.

Although this is the first time localized late blight forecasting has been attempted, USDA plant pathologists say that research trials of a similar nature in previous years indicate that the system will work effectively. In addition, analysis of 52 years of weather records in which occurrence of late blight was related to certain combinations of rainfall and temperature, showed that presence or absence of the disease could have been correctly predicted 92 per cent of the time.

Late blight will be forecast following 10 days of weather favorable to the disease (a total of 1.2 inches of rain and a mean temperature of 77 degrees F. or below).

Dr. Russell Hyre, plant pathologist with USDA's Agricultural Research Service actively cooperating with the Maine Experiment Station, has been on the job, headquartered at Presque Isle, since June 1. By survey he has established the major sources of possible late blight infection — the "hot sots" usually associated with piles of cull potatoes.

He is currently keeping a close check on weather conditions as wind, temperature, and rainfall play important roles in the spread of late blight spores and development of the disease. The Maine Extension Service reports these conditions by press and radio, and at county-wide meetings to potato growers. This way, growers will be able to apply protective fungicidal chemicals to their crops before late blight infection can occur. Timely fungicidal treatment can help prevent infection, but once the disease becomes established, there is no known cure.

MACHINE AUTOMATICALLY TIES FILM BAGS

A machine that ties film bags automatically has been announced by Plas-Ties Company, Santa Ana, California.

Designed for use with the company's vinyl covered wire tape, the Plas-Tie Matic bag closing machine is said to be capable of handling as many as 40 bags per minute, ranging in capacity from ½ to 25 pounds.

Bags are fed by hand into the machine which automatically cuts off the proper length of tie, fastens it around the neck of the bag and twists the two ends of the closure together to form a tight, neat seal.

Plas-Ties bag closures used in Plas-Tie Matic bag closing machines are available in colors and may be imprinted to customer's order. They are manufactured from virgin vinyl plastic and have a strong iron wire core making them freeze-proof, waterproof and easy to untie without damage to the bag or its contents.

Plas-Ties may be re-used many times, a great advantage to housewives, particularly, whose re-use of the plastic bags has contributed to the overwhelming success of polyethylene in the packaging field.

Plas-Tie Matic is also said to cut labor and material costs for closing plastic bags, as compared to doing the same thing by hand. Mention this publication in your correspondence.

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